

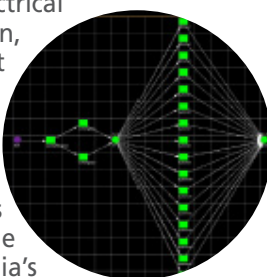
Wind Energy Programs

The Energy Security program area accelerates the development of transformative energy solutions that will enhance the nation's security and economic prosperity.

Sandia National Laboratories (Sandia) conducts applied research to increase the viability of wind technology by improving wind turbine performance, reliability, and reducing the cost of energy. Sandia specializes in all aspects of wind-turbine blade design, manufacturing, and system reliability. By partnering with universities and industry, Sandia works to advance the state of knowledge in the areas of materials, structurally efficient airfoil designs, active-flow aerodynamic control, and sensors. Researchers at the laboratory are investigating integrated blade designs where airfoil choice, blade platform, materials, manufacturing process, and embedded controls are all considered in a system perspective. By collaborating with operators, developers, and manufacturers, Sandia evaluates known reliability problems and develops tools and methods to anticipate and investigate future reliability issues.

Reliability Database & Systems Analysis

In order for wind generated energy to reach high electrical market penetration, customers must have continued confidence in the quality, durability, and reliability of wind turbines throughout the fleet. Sandia's reliability effort aims to ensure high fleet operating performance levels, judged both by energy delivery and low operating costs. This task measures, analyzes, documents, and publishes current and future turbine and wind farm availability, as well as targets potential reliability issues as early as possible. To accomplish this, the program initiated a national reliability database, which is used to gather and store wind farm operations data. These data are analyzed and baseline statistics on the reliability of the fleet are reported. The program will use these analyses



to initiate technology improvement projects where critical reliability issues are discovered. Manufacturers and key stakeholders will be invited to participate in addition to wind plant owners and operators. Building from the Sandia-sponsored public Wind Turbine Reliability Workshops of the past two years, Sandia will continue to build partnerships across the industry and facilitate information exchange to bridge the gaps between operators, developers, turbine suppliers, and component vendors.

Large Turbine Technology: Wind Turbine Blades

Blades are the only wind turbine component designed and manufactured uniquely for wind energy applications. The challenge is to create the scientific knowledge base and engineering tools to enable designers to maximize performance at the lowest possible cost. Activities at Sandia seek to produce research results, tools, and prototype evaluations necessary for the successful implementation of advanced design concepts into large innovative utility-grade blade designs. By focusing on improvements in blade technology through improved materials and manufacturing, optimized sensors, improved aerodynamic and structural codes, and enlarged rotors made possible by adaptive techniques, Sandia is providing innovative solutions to the industry.

Materials & Manufacturing

Wind turbine blades constitute a significant portion of the cost of a modern, utility-scale, wind turbine. These blades are comprised of relatively low-cost composite materials with manufacturing processes that are labor-intensive. To facilitate the incorporation of larger blade designs into new turbines, Sandia studies composite materials and manufacturing processes to develop innovations that will help reduce the nonlinear growth in blade weight. The objective of this effort is to provide innovations in materials, manufacturing

processes, and embedded sensor technologies that will deliver high quality, reliable, and cost-effective blade designs.

Innovative Concepts

As wind turbines become larger and heavier, blades that incorporate small load-control devices (similar to but smaller than flaps on an airplane wing) and embedded sensors to alleviate fatigue loads offer a potential for improving efficiency and energy capture. Sandia's efforts focus on three areas: (1) analyzing aerodynamic performance (2) developing advanced controls and (3) calculating the maximum potential cost of energy reductions that can be reasonably achieved by reducing fatigue loading. Finally, as technology allows blades to grow larger (to capture wind energy more efficiently), they are becoming difficult to transport over the nation's roads (currently, truck transporters are exceeding 180'). Sandia is investigating the possibility of economically manufacturing segmented turbine blades.

Aerodynamic Tools & Aeroacoustics

Sandia continues to develop and use computational fluid dynamics codes to improve our understanding of the highly 3-D flow fields under which wind turbine rotors operate. By leveraging Sandia's high performance computing capability, these tools provide the necessary information to develop the next generation of wind turbine blades that maximize both structural and aerodynamic efficiency. Additionally, Sandia will continue to develop aeroacoustics emission and propagation codes that will allow us to predict the noise characteristics of wind turbine rotors. As part of that effort, the aerodynamic performance and acoustic emissions of a rotor

with blunt trailing edge airfoils will be compared to those of a similar rotor with conventional airfoils and the effects of varying blunt trailing edge treatments on these characteristics will be studied. This comparison effort is supported by wind tunnel tests to compare the measured noise generation and propagation of a traditional sharp trailing edge airfoil and a structurally efficient flatback airfoil.

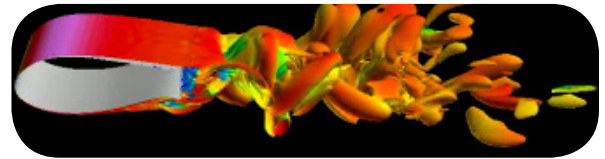
Design Tools & System Modeling

Sandia will continue its efforts to develop computational tools to significantly improve the structural and aeroelastic analysis capability available to the wind industry. These analytical capabilities may be used to guide the design of new blades as well as to verify/improve the design of existing blades. The validity

of the tools will be demonstrated by continuing a comprehensive design, analysis, build, test, and validation program. A major focus is being placed on better integration of the structural analysis and aeroelastic codes. This effort will reduce design time and lead to better and more efficient designs for future turbine hardware.

System Performance & Blade Testing

Full-scale testing of prototype wind turbine blades is vital to assess the structural and aerodynamic performance of advanced concepts. Recently, Sandia has developed three advanced blade designs which are in the process of being evaluated by a series of structural and aerodynamic tests. Sandia will continue to conduct both laboratory and field testing of advanced blades in the future, and provide the necessary results to industry to ensure the viability of



the unique features of the designs. Additionally, results from the blade testing provide the critical information needed to validate and improve our design codes.

Integration Technology Assessment & Support

Though wind turbine systems continue to improve, the success of wind energy in the marketplace increasingly depends on the ability to integrate wind effectively into the existing power grid and address the barriers associated with large-scale deployment. In order to address these challenges, Sandia supports several research activities to determine and mitigate the effect of wind turbines on civilian and military radar systems, and provide the analysis necessary for successful wind integration. Sandia

will continue to provide support to the wind integration analysis effort by collaborating with the appropriate utility/grid operators and relevant stakeholders. Additionally, Sandia is actively participating in DOE's Transformational Energy Action Management initiative through the analysis of an on-sight 30 MW wind farm that would tie into the Sandia distribution network and be used by both Sandia and Kirtland Air Force Base.

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